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Efficiency of Abrasives in the Working of Glass

By Jacques Wolf[1]

IN the grinding of glass a higher rate of output generally calls for a fairly thick grain. On the other hand, if fineness of the work is particularly aimed at, it is preferable to use a medium sized or fine grain.

The same principles are applicable to grindstone work but other factors interfere. For instance, if the character of the ground surface requires a rather thin grain, it is possible by means of an automatic machine to secure this even with a coarse grain grindstone. In this case it is a question of increasing the speed of the object to be worked while reducing the speed of the grindstone until best results are obtained. Rough grain grindstones are better adapted to machines of stronger power than are those formed of finer grains. The same thing holds for work on large surfaces, such as the smoothing of mirrors for which abrasives of large grain are best suited.

The great bulk of the mechanical abrasive working of glass is done by means of sand. For the surface work in the glass factory the size of the grains varies according to the different stages of the work. Heavy sand is used in the first place; then thinner sand is employed gradually for the other stages. Finally, sand may be substituted by pumice stone of various degrees of fineness. Emery and carborundum are employed in some cases for special work.

However, the use of abrasive material in grain or powder form is generally not sufficient to effect the complete grinding of glass except for certain kinds of engraving which necessitate, in the majority of cases, besides the powdery abrasive materials, the use of abrasives in the form of grindstones.

Grindstones play a prominent part in the mechanical working of glass. They may be divided into three classes: rotating discs, natural stones, and artificial products.

The rotating discs include cast iron discs applied in the first stage of grinding and in which they play the part of grindstones by drawing the abrasive sand against the object to be treated, without, however, acting directly as an abrasive.

The natural stones are limited to different sandstones. They are secured in various quarries and essentially are composed of amalgamated sand. The great difficulty with these is that their constitution is variable. From the appearance, color and previous experience with stones from any quarry the qualities of the stones can be determined with certainty. However, the natural stones often cause surprises during the work, due chiefly to variations in resistance, hardness and composition in the different parts of the stone.

The artificial grindstones include the majority of the stones used for working glass and similar materials. They have been made in grades comprising all degrees of hardness, resistance, and fineness desirable for work of any character. The manufacture of grindstones requires the uniting of abrasives into a compact uniform body of a definite cutting power. This amalgamation can be obtained in different manners, according to the nature of the agglomerating matter and the process of manufacture.

The most important of the manufacturing processes is the ceramic process which is especially adapted to grindstones, and stones of carborundum and emery. In this process the grains are crushed into a certain fineness, are sifted and washed at various intervals and finally are mixed with agglomerating matters, usually compositions of ceramic frits. This mixture is placed into molds and after having undergone a strong hydraulic pressure is introduced into a vitrifying kiln. At red heat all the agglomerating matter fuses and forms a ceramic coating around the abrasive grains, transforming the mass into a hard and porous stone, which has considerable resistance, to mechanical forces as well as against water and fluctuations of temperature. The great majority of grindstones for glass working are made in this manner.

For the larger size grindstones, such as for the cylinders and large beveling machines, the "one piece grindstones" have been substituted by "segment grindstones." This system presents decided advantages. The handling of large grindstones always entails a fairly great risk, as they possess considerable weight. The fitting-up is easier to effect in segment construction and the space between the segments reduces the danger of cracking through over-heating during the work. Moreover, turning out a segment grindstone presents fewer difficulties and thus reduces the cost.

The utility of a grindstone for a given job is determined by various properties, among the foremost being the abrasive material, the character of the grindstone and the technique of the work.

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The influence of the abrasive matter upon the properties of the grindstone includes the sizes of the grains and to a certain extent, the hardness and nature of the abrasive itself. The fineness of the grain must be previously checked before manufacture.

The properties of the grindstone itself, refer to the hardness of the material, which is quite a different matter than the hardness of the abrasive. By "hardness of the grindstone" is meant the solidity of the uniting matter or rather the degree of resistance to breakdown. It represents the faculty possessed by the abrasive grains of disengaging themselves from the uniting matter as the protuberances gradually wear out. Upon this resistance of the uniting matter rests much of the value of the grindstone.

The hardness of a grindstone, which has no relation to its color, as is sometimes believed, depends upon various factors such as: (a) the nature of the abrasive, (b) sizes of the grains, (c) resistance of the uniting matter, (d) distance between the grains, (e) sizes of the pores.

Each of these elements cannot be dealt with in detail, but it should be pointed out that large pores and small spaces between the grains reduce the hardness of the grindstone, while a resisting uniting mass and tiny pores increase it.

The hardness of grindstones is generally indicated in the trade by means of letters but occasionally according to a numbered scale. However, these indications are merely employed for comparison and as a rule do not represent a definite denomination of an equal degree of hardness by various makers.

A "scale of letters" generally indicates the properties of a grindstone by a figure followed by one or two letters such as for instance, 34 C U, the figure 34 meaning the size of the grain and C showing that same is combined with a finer grain, while U indicates the degree of hardness of the grindstone.

Applied technique plays an important part in the output of the grindstone and will be considered from various standpoints.

(a) The matter to be treated.

The hardness of glass often differs, but in practice it is not possible each time to change grindstones for a difference of glass hardness. As a general rule, for glass working, a grindstone with a grain from "coarse" to "fine" or of a hardness varying from "mean" to "hard" is employed. It is preferable to use a hard grindstone for a soft glass and a medium stone for a hard work.

(b) Kind of work.

Under the above circumstances the output of the grindstone depends a good deal on the kind of work undertaken, not only as regards composition and hardness as related to the matter to be treated, but also as concerns the shape. For instance, the hollow grindstones, or ring shapes, must be less hard than a flat shaped grindstone operating in the same conditions. On the other hand, the output depends at the same time on the quality of the product that is to be cut. The question to decide at the beginning is whether a stone producing a fine surface and average output, or one of greater output and cutting an average surface fineness is required.

The shape is determined by the form of the article to be operated upon. For cutting of large pieces or on large surfaces, grindstones must be used that bite the glass on a large area. In such a case the pressure exerted during the work, between the treated object and the grindstone, is spread over a larger extent, so that each grain suffers a subdued pressure. This must be taken into account, otherwise the grain does not disengage itself at the opportune moment when the ridges are blunt. The shapes and sections of the grindstones may be varied, depending directly on the kind of work to be done viz., a flat grinding, sharp corners, engraving, etc.

(c) Method of working.

The grinding may be dry operated or some liquid may be added during the work. Water or a little oil may be used as well as a potassium solution or boric acid. Liquid operation preserves the grindstone in good state for a longer time.

(d) Hand and automatic operation.

The differences between these two classes of work are ascertained by the sizes and shapes of the objects and consequently from the hardness and fineness of the grindstone. The speed of the carriage of the machine and the way in which the work is effected are apt to influence to a certain extent the output of the grindstone. In general grindstones of a large diameter are more efficient for machine use than are the others. They may be harder and can be used on a larger surface because they require less frequent adjustment. The grains may also be thicker.

(e) The Speed of rotation.

The latter is a factor the importance of which is often overlooked. It is the cause of many complaints regarding the quality and output of a grindstone, while the cause really lies in the circumferential speed of rotation being poorly chosen. As a matter of fact the speed of rotation represents the dynamic element of the mechanical action and the basis of the work. For a normal output, the circumferential speed of a grindstone may vary between 20 to 30 meters (65 to 100 ft.) per second according to the work undertaken and the constitution of the grindstone. Higher speeds present inconveniences as regards the work and constitute a danger through possible splitting of the grindstone.

The speed of rotation is in direct relation to the circumference of the grindstone. Consequently, for a given speed, the number of revolutions must vary according to the dimensions of the grindstone. As the edges of the grindstone gradually wear out and thereby its diameter decreases, the number of revolutions must be increased. Very often this gradual alteration is not taken into account so that ultimately the speed becomes insufficient, the grindstone wears out more quickly and leaves the impression of having been softer in the center.

THE USE OF GRINDSTONES

Besides the elements determining the properties of a grindstone as concerns the fineness, hardness and shape, its output is subject still to other conditions of technical order such as:

1. The fitting up.
2. The upkeep.
3. The wear.

Among these factors could also be quoted the speed of rotation but considering that the latter rather constitutes a collaborating force to the mechanical work itself, it has been treated in the technique of operation.

(1) Fitting up.

In the fitting up lies the fundamental work upon which depends directly the good operation of the machine and the output of the grindstone inasmuch as in the latter, are united all the requirements for the operation on the object to be treated as well as the conditions of work. It must be borne in mind, in the first place, that a grindstone is a fragile implement which will have to undergo very considerable internal tensions due to the centrifugal force increase in relation to the square of speed. Consequently the slightest splitting of the grindstone, during the work, may be apt to produce a burst under the influence of this force.

Moreover, it is well to know that even an impeccable grindstone may burst through defective fitting up causing abnormal tensions, by a play between the supports and the grindstone, or by a bad fastening. The tendency of the piece to be caught, during the work, between the support and the grindstone may instantly stop the motion and cause the breaking of the grindstone. However, the greater part of the accidents from the bursting of a grindstone, are caused by a defective fitting up, an exaggerated speed, or by a splitting.

Before proceeding to fit up a grindstone, it is always prudent to ascertain whether the latter is unbroken, by ringing it, that is to say by striking it lightly with a hammer. If the ceramic or mineralogical grindstone does not contain any crack, it will ring clearly. It must be borne in mind that for this test the grindstone must be well dried, very clean and held freely on the axle.

The main conditions of a good fitting up are:

(a) an impeccable state of the machine, that is, there should not be any trepidations or play in the axles or foundations.

(b) the grindstones must be handled with care and allowed to slide on the axle without pushing or striking with a hammer.

(c) the grindstone when fitted up must not be too tight at any point but must merely be gripped between two tightening discs and sufficiently upheld by nuts fitted on the shaft.

The tightening discs need a diameter of at least a third, usually the half of the diameter of the grindstone. In order that they may tighten the grindstone at their periphery, they are somewhat hollowed out towards the centre. The discs each side of the grindstone must be of the same dimensions.

(d) Before definitely placing the grindstone, it must be well balanced in order to obviate the trepidations which not only tax the axles but cause defective cutting and breakage of the object being treated.

(e) Before commencing any grinding work a newly fitted up grindstone must be allowed to run a few minutes in full speed of rotation. Then too it is preferable not to tax the grindstone immediately at the outset of a hard grinding, so as to avoid danger of bursting. After a grinding operation in which a liquid is employed care must be taken that the grindstone be partially covered with water otherwise splits or local absorptions of water may result in its becoming unbalanced.

The grindstone, due to its work is subject to alterations caused by the wear. Actually, a grindstone is an embodiment of small and sharp tools in the shape of grains, which take away tiny and lengthy sheaves of glass. Theoretically such a stone is up to standard when the grains may disengage themselves from the agglomerating matter just at the moment when the ridges are curved and can no longer furnish a sufficient cutting action. However, the large number of factors resulting from the practical work or the material are apt to alter this equilibrium.

When good quality grindstones are employed, the grains fall under the action of work at the opportune moment and the grindstone will wear out uniformly and completely. The alteration in equilibrium which may come about after a certain time by the uneven wear-out at certain places, must be attended to. The wheel should be so adjusted that it can turn freely again.

An abnormal wear, having its source in defective working such as too high a speed, renders the grindstone incapable of following the movement. The hardness then appears relatively too high and the grains do not fall. The glass sheaves becomes smaller, shape themselves into little balls and the abrasion is defective. The grindstone itself no longer gives off its hissing sound during the work, but becomes more sonorous while its surface turns glossy in appearance. A blunt grindstone requires a stronger pressure from the stone to produce an abrasive effect while the consumption of motive power increases and the object under treatment overheats.

If the grindstone is too fine, the pores get clogged up and it is not possible to turn out any proper work. On the other hand a too soft grindstone, or one of too little fineness, undergoes an abnormal wear with a too quick tendency in this direction to get unbalanced or lose its smoothing capacity.

Practically all the grindstones, and chiefly those of natural stone, undergo a certain abnormal wear-out, owing to the conditions or being used for more or less variable types of work. A certain pounding, glossiness, or deformation takes place after some time.

If the pores have been stopped by glass sheaves, it is only necessary to "dress" the grindstone in order to revive its biting effect. For this, so-called "grindstone dressers" formed by one or two small distended corrugated wheels fitted in a grip like the glass cutter, are used. It is always useful to treat the grindstone in this manner to revive its ruggedness and efficiency. The wheel dresser may be substituted by a stone of appropriate hardness and grain.

The Turning: This is a more energetic operation having a twofold object in view. It is not merely a question of reviving the ruggedness by doing away with the filth in the pores, but of reviving the grinding quality of a blunt grindstone by taking away the thin superficial layer containing the abrasive grains in which the ridges are worn out. In practice the grinding of objects of various shapes after a certain time brings about an uneven wear-out, so that the grindstone loses either its surface grinding capacity or its strictly circular shape. In both cases the grindstone must be turned in such manner as to recover the initial shapes after having eliminated a sufficient quantity of abrasive matter.

The turning is carried out by means of a diamond of size appropriate to the grindstone's dimensions. This diamond is fitted into a steel or copper handle in such manner that only its cutting edge can be seen. Diamond turning of the grindstones of automatic machines, is not always done by hand and

in these cases the handle is placed into a steel device adapted to the machine.

When a fairly thick layer must be taken away from the grindstone it is best to proceed by several consecutive turnings of small thicknesses, rather than to work to a definite level from the outset. It is to be borne in mind that a new grindstone of natural stone, which first put into use, generally requires to be turned as much for the shaping as to reach a characteristic layer of abrasive matter.

Sometimes the hand turning is carried out by means of a drill similar to the one used by stone-cutters. This system is not to be advised for not only does it cause a considerable loss of abrasive matter, but the frequent shocks are liable to bring about cracks.

The Annealing of Commercial Glassware

By F. W. NOEL

(*Continued from Page 178, November Issue.*)

Inhomogeneous Glass

INHOMOGENEOUS glass can quite easily be mistaken for stressed glass when an examination of a section is being carried out. It will not be digressing, therefore, if a few words are devoted to this important sidelight on annealing before the main subject is continued.

Inhomogeneity in glass is due to numerous causes, among which may be mentioned the following:

(a) Badly proportioned batch materials.
(b) Lack of uniformity in grain size of batch materials.
(c) Insufficient mixing of batch materials.
(d) Demixing, due to segregation of the heavier ingredients in the batch during conveying, elevating, etc.
(e) Too low a melting temperature.
(f) Variation in melting temperature.
(g) Variation in output or "pull" of glass from the tank.
(h) Inclusion of foreign soluble bodies such as refractory linings.
(i) Lack of uniform working temperature.

It is obvious from the list of some of the probable causes of inhomogeneous glass that it is a defect exceedingly difficult to eliminate and indeed, in the case of hollow ware at least, it appears to be the rule rather than the exception.

Inhomogeneity can be described as the variation in the composition of the glass throughout its mass, the variation being sufficiently marked in some cases to be detected by analysis. In most cases, however, the variation in composition although visible as very definite streaks or laminations both in diffused light and in polarized light, is not sufficiently marked to be detected on ordinary analysis. At the same time, the various layers of glass which constitute an inhomogeneous mass vary sufficiently in composition to possess different physical characteristics such as expansion, conductivity, density, etc., and it is due to these variations that small local stresses are set up during the annealing process. Inhomogeneous glass, therefore, due to the small but definite differences in physical properties, cannot be entirely freed from stresses, although these stresses are of quite a different nature from those set up during rapid cooling. An inhomogeneous glass can still be well or badly annealed and will function accordingly; on the other hand, a glass possessing very marked inhomogeneity can never be well annealed. The question arises, then, as to the procedure to be adopted in order to differentiate between actual stressed glass caused through a badly controlled annealing process and stresses set up through inhomogeneity.

Inhomogeneity exists in several forms, which can be broadly classified into what might be termed "uniform inhomogeneity" in which the stresses appear as regular and sharply defined layers usually disposed parallel to the surface, and inhomogeneity that is visible as a confused mass of intermingling layers and streaks that are entirely without definite order. Neither form of inhomogeneity has a measurable effect on the strength of the glass unless very marked.

Badly inhomogeneous sections of the glass will appear as vivid streaks of color when viewed in the polariscope using the selenite plate, indicating a sharp discontinuity in the composition of the glass. This type of inhomogeneity can be dangerous and should in all cases be treated with suspicion.

Cases have also been observed where a streak or lamination of inhomogeneous glass has set up severe tensile stress on the outer surface of the glass and so considerably weakened the article to thermal shock. This occurs when the laminations are disposed parallel to and in close proximity to the outer surface and when they consist of substances such as alumina or magnesia which have a smaller coefficient of expansion than the parent glass. During the annealing process there will be the tendency for the outer surface, having the greater coefficient of contraction, to occupy a smaller volume compared with the inner lamination, but this will be partially prevented by the inner lamination itself. The outer surface and the glass immediately adjacent to the inner lamination, therefore, become in extension, while the lamination is in a state of thrust. Tensile stress set up in this manner on the outer surface of the glass is very dangerous.

Confusion may again occur at this point in assuming that tension can only exist on the outer surface due to inhomogeneous laminations of the type already referred to. It will be pointed out later, however, that under certain conditions tension can quite easily be established on the outer surface of a perfectly homogeneous piece of glass if proper precautions are not taken in the annealing process.

On the other hand, it is quite conceivable that inhomogeneity can set up uniformly disposed layers of stress which can readily be mistaken for stress due to improper cooling. In such a case a test must be carried out in order to ascertain the cause of the stress. In order to view the sample of glass under examination to the best advantage, it should be immersed as explained earlier in a bath of liquid of similar refractive index as the glass itself. Having noted by this means the disposition of the lines and areas of stress in the polariscope the sample should then be examined, while still im-

mersed, in ordinary light. If the stresses are due to inhomogeneous laminations, then shadows should occur corresponding to the position of the stresses seen in polarized light, owing to the fact that the laminations possess refractive indices different from the parent glass. If these shadows are not visible, then, in all probability the stresses are actual ones set up by improper annealing. A final test, however, can be applied which will remove all doubt. The sample is first carefully examined in the polariscope and a record or sketch made of the appearance and kind of stress present. The sample is then well annealed either in a lehr or a bench furnace and again examined. If the stresses have disappeared, they were obviously due to bad annealing in the first place. On the other hand, if the appearance of the sample has not appreciably changed, then the stresses were due to inhomogeneity.

Effect of Stress on the Strength of the Ware

Having considered the various types of stress which can be established in glass, it now remains to discuss what effect they may have on the thermal and mechanical strength of the article.

It has already been pointed out that Zschimmer[13] claims that the best "annealing" for a bottle is to set up a uniform compressive stress on the outer surface of the ware.

McSwiney[14] states that "badly strained" glass is harder, more elastic and has greater crushing and tensile strength than the same glass when annealed. In addition, a bottle which is strongly and uniformly strained will show double the resistance to internal hydraulic pressure than is shown by the same bottle when well annealed.

Littleton[15] determined the tensile strength of annealed and stressed glass and found that as the initial strains increased, the tensile strength also increased. Highly strained specimens had a strength of 14.74 kilograms per square millimetre whereas for annealed specimens, it was 7.20 kilograms per square millimeter. In other tests, the tensile strength of stressed glass was over 60 per cent greater than in the case of annealed glass.

Much more corroborative evidence could be quoted if space permitted, but the conclusions reached by most investigators is the same, i.e., that a uniformly distributed compressive stress on the outer surface of the glass considerably increases its mechanical and thermal strength.

When one calls to mind the large difference between the resistance of glass to tension and compression, it is not surprising that an article is stronger when protected by radial and circumferential compression. The average resistance of glass to tension is about 7 kilograms per square millimeter, while the resistance to compression is over 100 kilograms per square millimeter.

Theoretically, all fractures in glass must originate at the weakest portion, that is, the layers in tension. Littleton,[15] in his experiments on the subject of tensile strength, actually observed that fracture occurred in the zone in tension and not at the surface of the test pieces. Obviously, then, tension on the outer surface must be avoided if the greatest possible strength is required.

[13]Sprechsaal, 61 (1918), S. 869.
[14]THE GLASS INDUSTRY, Nov., 1926.
[15]Phys. Rev. 1923, 22, 510.

The problem now resolves itself into two main questions: how is tension set up on the outer surface and how can it be avoided?

Tension can be set up on the outer surface first in the annealing process as a permanent stress and secondly during the life of the article as a temporary stress during hot filling, pasteurizing, etc. If it is set up during the annealing process, then it is more than probable that the article will fracture during hot filling, pasteurizing, etc., when the tensile stress is increased by those operations. On the other hand, if tension has not been established permanently during the annealing of the article, then the possibilities are that it will survive such operations as hot filling, pasteurizing, etc., provided they are not too severe.

It has already been considered under the section devoted to "Inhomogeneous Glass" how tension can be set up on the outer surface of the article due to inhomogeneity. Tension, however, can also be permanently established on the outer surface of perfectly homogeneous glass if proper precautions are not taken in the annealing process. This may occur very easily with panelled or flat-sided articles, such as those possessing square, rectangular or octagonal sections. Consider the case, for example, of two wide neck containers having flat sides, situated in the lehr with two sides or faces actually or very nearly in contact. The surfaces in contact have not the same facility for cooling as the corresponding surfaces inside the bottles. Consequently, the inside surface of a bottle cools quicker than the corresponding outer surface in contact, and a temperature gradient is set up which can only result in tension being established on the outer surface.

Tension can also be set up on the outer surface of bottles stacked close together or in contact in the lehr, due to the bottom and those sides not in contact cooling more rapidly and becoming set before the sides in contact. The tendency to contract of the sides is prevented by the rigid sides and bottom, under which condition they become in extension. Tension set up in this manner is particularly observed in the case of narrow neck ware.

The remedy in such cases as the foregoing, of course, is obvious. To ensure that all parts of the bottle cool at a uniform rate, sufficient space should be left between rows of bottles in the lehr and also between individual bottles in the same row to allow convection currents in the lehr tunnel to dissipate the heat from all surfaces of the bottle alike.

Tensile stress of a temporary nature is set up on the outer surface of a bottle during certain filling operations, pasteurizing, stoving, etc. For example, when the contents of a bottle are introduced hot, there is the immediate tendency for the surface inside the bottle to expand. This expansion is resisted by the outer layers, which are at a lower temperature. Owing to the tendency of the inner surface to occupy a greater volume, therefore, it becomes in compression, while a corresponding tensile stress is set up on the outer surface of the bottle. If the tensile stress set up in this manner is greater than the actual tensile strength of the glass, the fracture of the bottle results.

In pasteurizing, after the filling operation, the bottle is heated from the outside causing a tendency for the outer layers to expand and become in compression while tension is in

this case set up on the inner surface of the bottle. During the cooling, however, the reverse is the case. The tendency for the outer surface to contract is resisted by the inner layers of the glass, the bottle and contents being at a higher temperature than the outer surface of the glass. The tendency for the outer layers to contract is therefore responsible for the setting up of a tensile stress on the outer surface. This condition is infinitely more dangerous than tension on the inside surface of the glass and it is actually this part of the pasteurizing process that is responsible for the majority of the fractures.

The foregoing are the chief causes of tension being set up on the outer surface of the glass and it will at once be realized that although tension may not be the outcome of the annealing process, it is still liable to influence the behavior of the bottle by being temporarily established during processing.

Strength to resist such shocks may be partly gained by introducing into the glass ingredients calculated to lower its coefficient of expansion, such as boric oxide, alumina, magnesia, etc. Infinitely better results are gained, however, if the tension established on the outer surface during annealing is entirely eliminated and that set up temporarily during processing is greatly reduced.

This can be achieved by deliberately setting up a uniform compressive stress by a controlled method during the annealing process, such as by increasing the rate of cooling while the glass is "solidifying." Either the actual temperature drop during this range may be increased by introducing additional means of cooling or by taking off a proportion of the hot gases, or, the actual time taken for the bottles to pass through the lehr may be decreased. In any case, the changes should be made gradually. After having been subjected to the change, bottles should first be examined in the ordinary way in the polariscope. Following this, a complete section should be cut from the bottle as shown in Diagram 1 and examined while immersed for circumferential stress in the manner previously described by noting the colors present and ascertaining their value.

It is, of course, difficult to explain what the appearance of the section should be like regarding color, as this depends on the thickness of the section, type of ware, type of polariscope, etc. In general, however, in a polariscope fitted with a selenite plate, the colors observed in the section should be blue and orange-red, whether tension or compression, and the colored band indicating compression should be uniformly spread over the entire outer surface. Colors more intense than those mentioned are not necessary.

Fortunately, it is not possible in an ordinary lehr to set up an intense circumferential stress uniformly without disturbing the balance or equilibrium of the total stresses between the bottom and sides. In other words, as the rate of cooling becomes more rapid, it is not possible for every part of the bottle to cool at the same rate, owing to variation in the thickness of the walls and also to variation of temperature through a section of the lehr tunnel.

By an examination of the bottle in the polariscope in the ordinary way, therefore, an approximate idea is gained of the point where the circumferential stress is nearing a desirable maximum. When stresses begin to appear when the bottle is examined whole, then there is the danger that the stresses set up on the surface layers are beginning to lose uniformity.

It is apparent that the procedure of deliberately setting up compression on the outer surface by an increased rate of cooling cannot be adopted unless the lehr conditions are such that perfect annealing can be obtained in the first place. There should first be a complete absence of stress when the bottle is examined whole in the ordinary manner in the polariscope and the rate of cooling in the lehr increased progressively to the point when there occurs the tendency to disturb the total balance of stress in the bottle, bottom and sides. Compression on the outer surface is an advantage only provided it is uniformly distributed and stress visible in other directions indicates that various portions of the glass have not been cooled at the same rate and are therefore not in equilibrium one with another. Such a condition when severe, is dangerous and although considerable compression may be present on the outer surface, the bottle is liable to fracture upon the slightest shock or disturbance.

Shock Tests

The increased strength due to compression being established on the outer surface is readily indicated by shock tests in which hot water is introduced into the cold bottle, reproducing as far as possible the process of hot filling, and immersing the bottle filled with cold water into a bath of hot water and vice versa, a laboratory reproduction of the pasteurizing process. It should not be overlooked, when carrying out the pasteurizing test, that it is the fall in temperature that gives the bottle the greater shock as tension is established on the outer surface. In addition, pressure and impact tests can be applied which also indicate the extra strength gained by external compression.

If comparisons are to be made between bottles annealed under different conditions, all factors influencing the shock tests must be maintained constant. In the hot filling test, the best procedure is to immerse the bottles in a bath of cold water maintained at a constant temperature, the bath being provided with a cold water feed and overflow to allow a stream of water to flow continually during testing. The temperature of the hot water should also be maintained constant during the test, preferably by means of a thermostatic device.

Considerable differences in the results can occur due to the method of filling. Not only does the rate at which the hot water is introduced into the bottle influence the result, but the point to which it is directed is also an important factor. For example, it is pointed out by McSwiney[14] that if the stream of hot water is allowed to impinge on the angle formed where the bottom of the bottle joins the sides, a much higher breakage may be expected than if the stream were directed on the bottom of the bottle and allowed to rise to the sides.

Bottles should be allowed to stand in the flowing stream of cold water at least ten minutes before filling in order to become uniform in temperature. The results of a shock test are preferably expressed as the percentage fractured for a given temperature differential, a minimum of fifty bottles constituting a test with a temperature differential sufficient

to break about one-half of the total quantity tested. Owing to the many factors influencing the results, a quantity less than fifty tested does not give a true indication of the average strength.

(1) The annealing temperature, and to some extent the viscosity, varies with the composition of the glass. These characteristics should be definitely determined for each kind of glass.

(2) The annealing procedure is based on the rate of change of viscosity with temperature.

(3) The point at which rapid cooling can commence in a precisely controlled lehr is 50 deg. to 60 deg. C, below the determined annealing temperatures for most commercial soda-lime glasses.

(4) The rate of cooling can be progressively increased by shortening the time taken for bottles to pass through the lehr, until a uniform layer of compression is established on the outer surface. This is provided the stress present in the bottle in other directions is negligible.

(5) A uniform layer of compression on the outer surface renders the bottle better able to withstand processing and general handling.

(6) External compression can be detected by an examination in the polariscope of a ring section cut from the bottle. The values of the colors seen when using a selenite plate, i.e., whether tension or compression, must first be determined experimentally.

(7) Tests should be applied to ascertain that the colored bands seen when examining a section are not due to inhomogeneity.

(8) The existence of tension on the outer surface of a bottle is very dangerous. It can be established permanently during the annealing process either by improper lehr conditions or due to the glass not being homogeneous. Tension can also be set up temporarily during the processing of the bottle.

(9) Routine tests reproducing as far as possible actual processing conditions should be applied to ascertain the extra strength gained by increasing the external compression.

Semi-Transparent Glass From Blast Furnace Slag

A TRANSPARENT aluminum glass from blast furnace slag is described in Bulletin 3, Engineering Experiment Station, Alabama Polytechnic Institute. The properties and suggested uses of an inexpensive glass made from blast furnace slag are discussed. The mix consisted of slag, sand, soda ash, sodium sulphate and arsenic trioxide.

The composition of the final experimental charge follows:

(A) 7 parts of slag plus 8 parts of sand plus 1.76 parts of soda ash.

(B) To 8 parts of the above mix, add 1 part of hydrated sodium sulphate.

(C) Add 1 per cent arsenic trioxide.

On a percentage basis, we have the following:

Wet Basis

(Per cent by weight)

37.21	slag
42.52	sand
9.37	soda ash
9.90	hydrated sodium sulphate
1.00	arsenic trioxide
Total 100.00	

NOTE: If *anhydrous* sodium sulphate is used, the slag amounts to about 40 per cent.

The above mix gave a pale green, transparent glass of high lustre, free from scum. The glass poured and worked very nicely, remaining soft for a considerable time. If this glass is desired for bottles, it is believed that it would work satisfactorily in automatic bottle machines. If it should harden too quickly for this purpose, increase of the alkali content should be beneficial.

It should be mentioned in this connection, that in special cases, the slag might be increased to a considerable degree and the sand reduced to a corresponding degree, without causing serious difficulty.

35 grams of the mix was placed in the hot fire clay crucible from a previous run. The average temperature of furnace and crucible at this time was about 1200°F. The crucible as it rested in the furnace was filled about two-thirds full of the charge.

The gas was then lighted, the air turned on, and the top placed on the furnace. The preheater was turned on, thereby gradually heating the air required for the combustion of the gas.

The temperature of the furnace rapidly increased. In 15 to 20 minutes, the charge began to swell. It was penetrated once or twice with a glass rod. Soon the charge subsided and quiet fusion took place.

An attempt was made to analyze the glass but so much difficulty was encountered, that it was decided that the composition could be more accurately calculated. The results calculated from the composition of the mix are as follows:

	Per cent by weight
SiO_2	64.90
CaO	20.18
Na_2O	8.75
Al_2O_3	5.17
Fe_2O_3	1.15
MgO	0.09
Total	100.24

In the above calculation, the theoretical yield of glass was 84.5 per cent, i.e., 15.50 per cent passed off as water or gas. It is assumed that there was no volatilization of the sodium. It is assumed further that the loss of sulphur is balanced by the arsenic remaining in the glass.

According to Prof. Basore of the Institute, the resulting glass is sufficiently transparent for bottles and similar articles

(*Continued on page* 197)

Glass Industry

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The Glass Industry takes this means of extending to all of its readers its best wishes for a Merry Christmas and a Happy and Prosperous New Year.

Foremen's Safety Conferences

THE experience of many companies in the prevention of accidents to employees is proving that the active co-operation of foremen is essential to a safety program if the maximum amount of improvement is to follow. Several plans have been developed to enlist the interest and intelligent participation of foremen in accident prevention. One of the most successful of these is to conduct a series of foremen's conferences at which all phases of safety work are discussed.

As a guide to organizations interested in developing the cooperation of foremen in promoting safety, the Policy Holders Service Bureau of the Metropolitan Life Insurance Company, has issued a booklet which offers suggested programs for a series of seven safety conferences, each conference to discuss one main phase of accident-prevention work. For each conference the report suggests nine questions to provoke discussion and gives complete answers to each question.

The material embodied in this publication has been developed from the programs used by a number of industrial organizations, and is confined to the fundamental principles of safety work as applied to all types of industry.

In the interest of a good cause we point out that a limited number of copies of the booklet are available to interested firms on request to the company's Policy Holders' Service Bureau, 1 Madison Avenue, New York.

The Chemical Engineering Catalog

The Seventeenth Annual (1932) Edition of the Chemical Engineering Catalog published by The Chemical Catalog Company, Inc., 419 Fourth Avenue, New York, maintains the high standards and comprehensiveness of previous editions and continues to serve in many ways and most effectively the industries employing chemical processes of manufacture. Its 80 page Classified Index of Equipment and Supplies is adequately arranged for convenient reference and cross reference. Proprietary trade names have been separated from the general index and now constitute an independent section. The Classified Index of Chemicals and Raw Materials fills nearly 160 pages. A comprehensive Technical and Scientific Books Section is included.

The Chemical Engineering Catalog enjoys the co-operation of a committee appointed by the American Institute of Chemical Engineers, the American Chemical Society, and the Society of Chemical Industry in supervising the compilation and formulating the specifications and standards published in the Catalog. The 1932 edition contains, in all, about 850 pages. Information concerning the wide distribution of this long established and highly useful publication may be obtained from the publishers.

Charles R. Crisp Qualifies as Tariff Commissioner

Charles R. Crisp of Americus, Ga., was sworn in as a member of the Tariff Commission on October 7. The President appointed Judge Crisp to fill the vacancy caused by the death on September 16 of Lincoln Dixon, of Indiana. The appointment is for the term ending June 16, 1937.

This brings the Tariff Commission again to its full strength of six Commissioners, as follows: Robert L. O'Brien, chairman, republican; Thomas W. Page, vice chairman, democrat; Edgar B. Brossard, republican; John Lee Coulter, republican; Ira M. Ornburn, democrat; and Charles R. Crisp, democrat.

Reference to the contents of earlier issues of THE GLASS INDUSTRY can be found in THE INDUSTRIAL ARTS INDEX in many Public and Technical Libraries.

Semi-Transparent Glass From Blast Furnace Slag

(*Continued from page* 195)

particularly if a relatively high grade sand, a large deposit of which is found in Alabama, is employed. Where an ordinary grade of building sand (SiO_2, 97.02 per cent, Fe_2O_3 1.09 per cent—see page 8, Bull. 3) is employed, a glass is secured which is somewhat less transparent. Objects near at hand are visible but objects at a distance of more than several feet are invisible when observed in ordinary day light or by artificial light. This glass adsorbs green (this glass is various shades of green) but diffuses the other components of the light. When a sheet of the glass is held several feet from the flame of a furnace heated to about 2,500°F. a diffused light passes through but objects are not visible.

It is believed that the effectiveness of the glass in diffusing the light is partly explained by the fact that the glass was poured on a rather rough surface (a heated steel plate) where it was rolled into a sheet by a heated polished steel cylinder, and partly by the fact that certain impurities present in the raw materials or added to the charge such as sulphur, arsenic trioxide or iron compounds were dispersed throughout the glass. Several samples of the glass when ground became considerably more transparent, which supports the first point. On the other hand, the glass still diffuses light to an appreciable degree which lends support to the second point. Furthermore, the degree of transparency depends somewhat on the quality of sand employed. Employing the *same* sand, the degree of transparency and to a considerable extent the color as well depends upon the quantity of arsenic trioxide employed. A small quantity of arsenic trioxide permits much of the sulphur of the slug to remain in the glass, the result being an amber glass. On increase in the arsenic trioxide, much of the sulphur apparently escapes as arsenic sulphide, the result being a pale green glass of greater transparency.

With regard to the way the glass permits light to enter, but obscures the vision of objects on the outside, the glass resembles much of the opal or "ribbed glass" now on the market. According to Hodkin and Cousen (Textbook of Glass Technology, p. 125), the slag glass probably is correctly defined as an "alabaster" glass since it diffuses light without materially altering its color. These authorities state that glass of this type contains appreciable red lead or litharge and niter. Judging from the composition of such glasses given as noted above, the cost of a ton of raw materials would probably be from $20 to $35, as compared to possibly $6 or $7 for the slag glass. Another "alabaster" glass mentioned by these men has a very high silica content (about 80%) and consequently probably has a high melting point.

Possible uses for the slag glass depending upon the light diffusing property, include its use as a substitute for opal or ribbed glass in windows and doors of shops and offices. It may be that this glass could be used for glass houses and buildings since it transmits light but objects remain invisible. The excellent resistance of the slag glass to corrosion by acids and alkalis, its toughness, its resistance to shattering and its high tensile strength are properties which would be of interest in connection with the above uses.

Society of Glass Technology

First Autumn Meeting

THE first meeting of the Society of Glass Technology for the session 1932-33 was held in Sheffield, October 19, with President Meigh as chairman.

A brief Introductory Address was given by the President who outlined the outstanding features of the programme proposed for the session and appealed for the united help and support of all members. He spoke of membership, its benefits, and demands, from the points of view of individuals, and then of the Society as a whole.

It was of great benefit to a scientific worker to be able to speak about his various investigations before his fellow workers and to have their criticisms and comments. Although much useful work was done by the hermit type, one could not fail to be helped and to develop new ideas if one were able to discuss freely theories and practical results with others engaged on similar work, and yet again with those engaged in the practical side of the industry. Thus, on the eve of a new session they came, not grasping for crumbs from others, but hoping to obtain opportunities of self expression so that the value of their future activities might be enhanced.

Turning to the consideration of membership from the point of view of a Society as a whole, Mr. Meigh referred to the great difficulties encountered in the past year by the whole of the industry. Difficulties, however, gave rise to proportionate opportunity. In the past the Society had not followed a stereotyped programme, nor stuck to any particular routine. New outlets and new problems had been found, and the next session would be no exception.

Looking back upon various problems it was evident that the more that was done and solved, the more there was to do. New avenues were opened up, and as our scientific method became more sure, so new and wider fields were discovered.

In conclusion, Mr. Meigh spoke of that outstanding feature of the Society, the friendly nature of all the functions and meetings. The more they meet and brought in the humanizing influence, the better would be the work performed.

Professor Turner gave an illustrated lecture on the scientific basis of glass manipulation with special reference to automatic glass forming machines.

At the outset Professor Turner explained how he intended to put forward certain leading ideas for discussion.

The fundamental factor in all working of glass was the property whereby, although a liquid at high temperatures, it did not suddenly solidify like a metal, but slowly passed through a plastic to a rigid state.

With the help of numerous lantern slides the speaker illustrated three methods for the conversion of molten glass into sheet for window glass. Into all these the factors of time and temperature entered. In all it was essential to develop an outer layer of sufficient rigidity to prevent deformation. In some processes of glass making there were discontinuities in the manipulation, due to the

need, at some stage, of re-softening this outer layer. The Fourcault process was an exception.

Four physical factors governed the manipulation of glass, namely, (1) viscosity, (2) rate of change of viscosity with temperature, (3) tendency to devitrification, and (4) rate of loss of heat by conduction and radiation. Since manufacturers took care to avoid compositions of glass likely to devitrify when working, that factor was not considered further.

Considering viscosity, values obtained for glasses similar in composition to ordinary bottles were given (along with others for glasses richer in alumina) between the temperatures 800°-1300° C. As would be remembered, the limits of viscosity for glass in working, as agreed with the German Society of Glass Technology, were 10^3 and 10^6 poises, but it was possible that these limits would vary for different processes. From the values given, it was evident that, if the setting rates were reasonable, the alumina-containing glasses could be worked as well as the ordinary lime glasses, provided that the glass was discharged from the furnace at a suitable viscosity. A higher temperature was necessary all through the working range, and better technique was called for, but the glasses were not unworkable.

Based on conductivity values at ordinary temperature, losses by conduction from the common machine-operated glasses were much the same, being governed largely by silica content. Numerous data were given of the initial working temperatures of lime-soda-silica glasses used for making plate, sheet, and bottles, both hand-made and machine-made. The loss of strength of bottles due to lack of homogeneity was stressed, and interesting illustrations were given of the formation of cords and striae in bottles made on suction or gravity fed machines, due to chilling in the mold. The effect of surface tension, of which, for glass, little was known, was also discussed. The preferential weathering of, or attack by steam on cords was clearly demonstrated, the phenomenon being similar to that obtained with metals. The probable action of gases on these cords in their formation was indicated.

The necessity of a re-heating period immediately after the transfer, in the automatic production of bottles was stressed, and the effect of mold temperature upon the length of time required for this re-heating were considered and calculations based on the law of radiation were presented.

Sets of data were given for bottles made on an O'Neill and on an Owens machine. The neck temperatures were always much less than those for other parts of the bottles. Further, figures were quoted for mold temperatures as obtained years ago by the Glass Research Association and by the Department of Glass Technology of Sheffield University. It was hoped that such very necessary basic data would be amplified by the Department of Glass Technology in order to help in defining the best conditions for manipulating glass. Professor Turner expressed a hope that members would be led to carry out measurements so as to extend the fundamental data necessary to build up a theory of the manipulation of glass.

THE LONDON SECTION

The London Section of the Society held their opening meetings of the new session in the Science Museum on October 5. Dr. C. H. Desch delivered an interesting lecture on "The Solid State."

Dr. Desch, who is the Superintendent of the Metallurgy Department of the National Physical Laboratory, gave a brief historical survey of the early conceptions of solids, liquids and gases, followed by a detailed resume of the latest knowledge on the structure of solids, with particular reference to the study of single crystals. The new theories were mainly applied to non-vitreous substances but the speaker concluded his address with a suggested application to the constitution of glass, by which he explained why glass could no longer be considered as an under-cooled liquid.

As the meeting was the Annual General Meeting of the London Section it was necessary to appoint two members of the executive committee to replace the two members who were required to retire under the rules of the Section. Mr. R. Sharp and Mr. A. G. Luraschi were elected to fill the vacancies. Mr. T. C. Crawhall, having agreed to serve as honorary secretary for another year, was re-elected. The business part of the meeting then concluded with the adoption of two resolutions concerning the rules of the Section.

The members were informed that the informal dinner, which is always such a successful feature of the London Section, would be held this year on Wednesday, December 14th.

Several Patent Infringement Suits Settled

Believing that the headline which appeared in the *United States Daily*, November 15, 1932, "Hearing Refused in Settlement of Infringement Suit" relating to litigation involving Steimer patent No. 1,564,909 and Peiler patent No. 1,573,742 might give the ordinary reader the impression that the Supreme Court has refused to consider or to uphold Hartford patents, the Hartford-Empire Company calls attention to the fact that "the effect of this refusal is to leave standing the favorable decisions obtained by Hartford-Empire Company in the Sixth and Eighth Circuit Courts of Appeals."

Decisions of the Court of Appeals in the feeder litigation, presented to the Supreme Court, involved the Hartford-Empire Company vs. Nivison-Weiskopf Co.; same vs. Kearns-Gorsuch Bottle Company; same vs. Lamb Glass Company and Lamb Glass Company vs. Hartford-Empire Company. "In some of these suits petitions for writs of certiorari were brought by both parties. The object in seeking to have these decisions reviewed by the Supreme Court was to obtain a decision from the highest court of appeals in certain different judicial circuits. There was a difference in opinion between the courts of some of these circuits, and in such cases the only way to determine which decisions or parts thereof are final and binding is to obtain a decision from the Supreme Court.

"On November 14 the Supreme Court refused to hear these petitions, for the reason that there is no longer any litigation between Hartford-Empire Company and the several parties named above as in every case the glass manufacturing company named has, since the filing of these petitions, taken a license from Hartford-Empire Company."

Simplified Practice Recommendation R123-30, Bureau of Standards, entitled Carbonated Beverage Bottles, is now available in printed form from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents.

Proposed Federal Specification for Laminated Plate Glass for Glazing Automobiles

A copy of Proposed Federal Specification for Laminated Plate Glass for Glazing automobiles was issued November 17 by the Federal Specifications Board, Washington, D. C. J. Lyman Briggs, acting chairman of the Board, would be glad to receive any comments or suggestions as to changes which may be thought to be desirable in the specification. Such comments or criticisms will have to be received by the Board not later than ten weeks after November 17, if they are to receive attention of the technical committee considering the subject.

Nov. 1, 1932.

A. Preamble.

There is no other Federal Specification applicable to this specification.

B. Types.

B-1. Laminated glass covered by this specification is of one type only, namely, laminated glass consisting of two sheets of ground and polished 7/64 in. plate glass between which is cemented a sheet of suitable plastic 0.020 in. thick.

C. Material and Workmanship.

C-1. See E. Detail Requirements.

D. General Requirements.

D.-1. Laminated glass shall be of such quality that, when the glass is broken by a blow, large pieces of glass do not break away from the plastic binder.

D-2. Laminated glass shall permit uniform vision, without distortion, and shall not contain objectionable defects.

E. Detail Requirements.

E-1. Dimensions.

E-1a. Plates must be cut within 1/32 in. of the dimensions ordered.

E-1b. Thickness.

E-1b. (1). The minimum thickness of plates shall be 7/32 in. and the maximum shall not exceed 9/32 inch.

E-1b (2). The thickness measured at various points on the plate shall not vary more than 1/32 inch.

E-2. Flatness. Plates shall not be bowed more than 1/32 in. per linear foot when the plate is laid on a flat table.

E-3. Overlap. An overlap of 1/16 in. of one sheet over the other on an unfinished edge intended to be set in a fixed channel or permanent frame shall be permissible on occasional lights, provided the over-all dimension of the plate is within the tolerance stated in paragraph E-1a.

E-4. Quality.

E-4a. Laminated glass shall be relatively free from haze, and shall be free from particles of foreign matter more than 1/32 in. in diameter, bloach, and separation.

E-4b. Occasional chips in the glass, on an unfinished edge, which do not extend more than ¼ in. into the plate nor beyond the channel frames in which the plate is to be set, are permissible. No chips should appear on polished edges.

E-4c. Variation in color from a very slight amber to a slight blue tint from plate to plate shall be permissible.

E-4d. There shall be no variation in color in individual plates when examined against a white background.

E-5. Sealing or Caulking.

E-5a. All edges of laminated glass intended to be set in permanent channels or frames where moisture is liable to collect, shall be sealed with some sealing or caulking compound. Other edges may or may not be sealed or caulked as specified in the order.

E-5b. Whenever a sealing or caulking compound is used around the edges of laminated glass, it shall withstand the tests described in Section F-3b (1) without decomposing, swelling so as to force itself from between the two sheets of glass, flow from between the sheets, loosen from them so that moisture can enter, or in any other way become objectionable.

E-5c. The sealing or caulking compound used on exposed edges shall not become sticky at any temperature below 49° C. (120° F.).

E-5d. Depth of sealing or caulking.

E-5d (1). On all polished edges the colored border resulting from edge sealing or caulking shall be uniform in depth on individual plates, but on different plates it may vary between 1/16 and 5/32 in.

E-5d (2). On unpolished edges, covered by channels or frames, sealing or caulking shall extend to a depth of not less than 1/16 nor more than 3/16 in.

E-6. Distortion of Vision. The plate shall have no defects that cause distortion of vision when the plate is viewed at an angle greater than 30 degrees. (See Section F-2b).

F. Method of Sampling, Inspection, and Test.

F.-1. Sampling.

F-1a. Samples to be used for tests described in Paragraphs F-3a, F-3b (2), F-3c, F-3d, F-3e, F-3f, and F-3g may be cut from full sized plates as delivered or samples shall be submitted by the manufacturer when requested by the purchaser.

F-1b. Samples to be used for test described in Paragraph F-3b (1) shall be furnished by the manufacturer when requested by the purchaser.

F-2. Inspection.

F-2a. The entire shipment of laminated glass shall be inspected for fulfillment of requirements stated in Sections E-1, E-2, E-3, E-4, E-5a, E-5d and E-6.

F-2b. The plate should be examined for distortion of vision (E-6) when held at arm's length with an angle of about 30 deg. between the plate and the line of sight and looking through the plate at an object containing straight lines, such as a brick wall. No distortion should be observed.

F-3. Tests.

F-3a. Adhesion Tests.

F-3a (1). Breaking Test.

F-3a (1)a. A 12 x 12 in. test specimen is supported in a wooden frame made from 1½ in. square lumber, mounted upon a flat concrete floor or a two foot square 1½ in. iron bed plate. The upper inside edge of the frame shall be rabbeted ⅜ in. wide by 7/16 in. deep, so as to give the specimen 5/16 in. support on all edges.

At least three specimens shall be tested and they shall be prepared for test by holding them at 24° C. (75° F.) for at least four hours before making the test, and the tests shall be conducted with the specimens at a temperature between 21° and 27° C. (70° and 80° F.).

F-3a (1)b. A ½ pound steel sphere shall be dropped freely from a height of 16 ft., striking the specimen within one inch of its center. The ball must strike the glass once only and must not be allowed to bounce on the glass.

The specimen should develop a great many cracks in the top and bottom sheets of glass, but should not break into separate pieces, though an occasional one may do so. If more than one of the three samples break into separate pieces the material shall be rejected. If only one sample fails, one additional sample shall be tested, and if this also breaks into separate pieces the material shall be rejected. At the point immediately opposite the point of impact, small fragments of glass may leave the plate, but this small area shall expose less than one square inch of plastic, which should always be well covered with tiny particles of glass adhering to the plastic. Separation between the plastic sheet and the glass which may result from the break shall not take place to an extent in excess of two per cent of the area of the test specimen.

F-3a (2). Crushing Test. Each of the three specimens used in the Breaking Test [F-3a (1)] shall be crushed by holding it in one hand and striking it repeatedly with a hammer, with a glancing blow, just hard enough to pulverize the glass and remove it from the plastic, without imbedding small particles in the plastic.

Small fragments of glass shall cover the entire surface of the plastic after the glass has been crushed, and the bare areas shall not exceed 50 per cent of the total area subjected to crushing.

F-3b. Humidity Tests.

F-3b (1). At least three specimens, 3 by 3 in., with all edges sealed or caulked are placed in a closed container over sufficient water to saturate the air in the container at 49° C. (120° F.) for two weeks.

F-3b (2). At least three specimens, 3 by 3 in., with no edges sealed or caulked are placed in a closed container over a saturated solution of sodium nitrate ($NaNO_3$) at 49° C. (120° F.) for two weeks.

F-3b (3). In the two tests outlined above (F-3b (1) and F-3b (2)), no separation of an objectionable nature shall develop. Small separation spots may sometimes result from hollow spots in the plastic or the glass, and shall not be considered objectionable. The sealing or caulking compound shall be examined for compliance with the requirements of Sections E-5b and E-5c.

F-3c. Boiling Test. Two specimens, with no edges sealed or caulked, approximately 3 x 3 in., are immersed in boiling water for two hours. At the end of two hours boiling no bubbles shall have developed more than ¼ in. from the edge. Bubbles at edge are caused by moisture penetration.

F-3d. Dry Heat Test. Two 3 by 3 in. specimens, with no edges sealed or caulked, are placed vertically and at least one inch apart in an electrically heated oven provided with means for adequately circulating the air so that the temperature of the specimens shall be uniform throughout. The temperature of the oven shall be between 74 and 77° C. (165 and 170° F.). The test shall continue under these conditions for 48 hours.

The specimens shall show no indication of decomposition of the plastic, formation of bubbles, or separation of glass and plastic. A slight amber tint which tends to fade upon exposure to ultra-violet light or sunlight is not an indication of objectionable decomposition.

F-3e. Discoloration Test. (Ultra-violet light). One 3 by 3 in. specimen is placed 9 in. from a source of ultra-violet radiation equivalent to that of an Uviarc Test Cabinet or Laboratory outfit of the 220 volt Cooper-Hewitt type. The light should be operated with 170 volts across the tube with a current of four amperes. The time of exposure shall be 200 hours. The temperature of the specimen should be maintained between 38° and 49° C. (100° and 120° F.) throughout the test.

Only a very slight discoloration, noticeable when samples are placed against a white background, should be found.

F-3f. Weather Exposure Test (Optional). Three 6 by 6 in. test specimens with finished edges are set in a vertical position in some exposed location, such as the roof of a building where they will not be disturbed.

Three edges of each specimen shall be loosely set one inch into either a wooden or metal frame lined with glazing felt which has not been treated with pitch or other moisture-proofing compound. The top edge of each specimen shall be exposed freely to the atmosphere. (If any edges are not sealed or caulked, at least one such edge shall be made the top edge). Samples shall be so spaced that the shadow of one does not fall upon another, thereby protecting it.

The specimens shall not develop noticeable defects during such exposure for six months.

F-3g. Light Transmission Test.

F-3g (1). This test shall be made on (a) the original specimen provided by the manufacturer, (b) the specimen after exposure to test described in F-3e, and (c) the sample after exposure to test described in F-3f, if this test was made.

F-3g (2). These specimens shall be tested for transmission of normally incident white light, and in no case shall the transmission fall below 70 per cent.

G. Packaging, Packing, and Marking.

G-1. Any special requirements of individual departments are noted under Section H.

G-2. Packaging.—Unless otherwise specified, commercial packages are acceptable under this specification.

G-3. Marking.—Each container shall be legibly marked with a description of the contents, the name of the manufacturer, the place of manufacture, the brand (if any), the dimensions and quality of the contents, and some means of identification of the particular contract on which purchase and shipment were made.

H. Requirements Applicable to Individual Departments.

H-1. The following departmental specifications, of the issue in effect on date of invitation for bids, shall respectively form a part of this specification.

H-1a. Army: Marking.—United States Army Specification. No. 100-2, Standard Specification.

H-1a (1). Packing.—For domestic shipments, current commercial packing which will insure delivery in good order. For export, War Department Specification for export packing current on the date of circular proposal.

H-1b. Navy Department: General Specification for Inspection of Material (copies of which may be obtained without cost upon application to the Bureau of Supplies and Accounts, Navy Department, Washington, D. C.).

H-1b (1). Plate glass shall be carefully and securely crated so as to prevent breakage.

H-1b (2). Glass up to 100 united inches shall be packed 50 square feet per box, glass over 100 united inches shall be packed about 100 square feet per box.

H-1b (3). Shipping containers shall be marked with the name of the material, the type, the size, and the quantity contained therein as described by the contract or order under which shipment is made, the name of the contractor, and the number of the contract or order.

H-1c. Marine Corps: Instructions issued by the Quartermaster's Department.

H-1d. Panama Canal: Packing-Glass to be securely boxed to insure against breakage due to rough handling in ocean shipment, the different panes of glass to be separated by a thin sheet of paper. Sides, tops, and bottoms of boxes to be made of good grade lumber not lighter than ⅝ inch thick. Ends or heads of cases to be made of S2S ⅞ inch thick hardwood. Sides to be adequately braced on outside with not less than two ⅝ inch by 3 inch battens. Ends to be adequately reinforced on outside with not less than two ⅝ inch by 3 inch cleats. Boxes to be well nailed with seven-penny cement-coated nails. All nails to be clinched on inside.

All space between glass and inner walls of boxes shall contain sufficient straw or excelsior to prevent contact between glass and any portions of the lumber used in the construction of the boxes.

H-1d (1). Alternative bid: If bidders desire to use their standard method of export packing for glass, and consider same equal or superior to the above specifications, they may submit alternative proposals based on such standard method of export packing. In case such alternative proposals are submitted, bidders should state in detail the method of packing proposed, such statement to be written on separate slip and pasted on the margin of this class. The Panama Canal reserves the right to reject such alternative bids if it does not consider the method of packing satisfactory.

To insure shipment of glass on the edge instead of flat, boxes shall be properly marked "Glass; this side up."

I. Notes.

I-1. It is believed that this specification adequately describes the characteristics necessary to secure the desired material, and that normally no samples will be necessary prior to award to determine compliance with this specification. If, for any particular purpose, samples with bids are necessary, they should be specifically asked for in the invitation for bids, and the particular purpose to be served by the bid sample should be definitely stated, the specification to apply in all other respects.

I-2. This specification governs all United States Government purchases of this commodity. Users are requested to retain this specification in permanent file until a revision is issued.

I-3. Interested parties are advised that an Alphabetical Index of Federal Specifications may be obtained upon application, as noted in paragraph next below, at a cost of 5 cents.

I-4. Copies of this specification may be obtained upon application, accompanied by money order or coupon, or cash, to Superintendent of Documents, Government Printing Office, Washington, D. C.

I-5. Glossary of terms used in these specifications.

I-5a. The various terms used in this specification for describing laminated glass and imperfections appearing therein are the following: plate glass, sheet, plastic, plate, overlap, unfinished edge, haze, cloud, foreign matter, bloach, separation, bubbles, discoloration.

I-5b. Definitions of the various terms are given herewith:

Plate glass.—Transparent, flat, relatively thin glass having plane polished surfaces and showing no distortion of vision when viewing objects through it at an angle. Plate glass is made at present by casting and rolling large sheets periodically or by rolling a continuous sheet. The sheets are then ground and polished.

Sheet.—A single thickness or piece of glass or plastic.

Plastic.—A sheet of thin, flexible, transparent, relatively colorless organic material, such as pyroxylin, pyralin or celluloid, cemented between two sheets of glass.

Plate.—A piece of laminated glass which consists of two sheets of polished plate glass and one sheet of plastic.

Overlap.—The extension of one piece of glass beyond its com-

panion piece, usually caused by slippage of one sheet past the other in process of lamination.

Unfinished Edge.—An edge which has not been finished by grinding.

Haze.—Dust-like appearance caused by the introduction of dust between the laminae, or by cloud in the pyroxylin, or by short finish of the glass. Any haze which is not readily detectable or which does not interfere with vision is not considered objectionable, as there is always a slight degree of haze to be found in all pyroxylin plastic.

Cloud.—Dust-like appearance caused by incompletely dissolved or partially nitrated cellulose, which is an inherent defect in pyroxylin, and cannot be entirely eliminated.

Foreign Matter.—Small particles of dirt or lint introduced between the plates in the course of fabrication.

Bloach.—Areas within the plate where the plastic and the glass on one side or another do not adhere and which therefore appear as dull unfinished areas.

Separation.—Areas in which the plastic and glass have originally adhered, but where they subsequently have parted from one cause or another. Such points usually show a dull reflecting area, and can be detected by holding the glass so as to reflect light at an angle.

Bubbles.—Areas where the pyroxylin and glass have been forced apart by the vapors of solvent or decomposition products released from the plastic by heat.

Discoloration.—Noticeable change in color of the laminated glass resulting from decomposition of, or photochemical changes in, the plastic.

Frazier Offers Cash for Standard Plate

The public sale of the Standard Plate Glass Company of Butler, Pa., has been postponed and the receivers have petitioned the Court of Common Pleas of Allegheny County, Pennsylvania, to authorize a private sale to C. E. Frazier of Washington, Pa., who has made an offer of $325,000 in cash for the property. The Court has set December 5, 1932, at 10 a.m. in the City-County Building, Pittsburgh, as the time and place for a hearing upon the above mentioned petition and creditors or stockholders desiring to make answer either for or against the propriety of making the private sale referred to above may do so. In the meantime any further or higher bids from any other person or persons with reference to the said property will be given consideration by the receivers.

Bristol Company Establishes Plant in England

The Bristol Company of Waterbury, Conn., has announced the establishment on October 1, 1932, of a British factory at London, England, under the name of Bristol's Instrument Company, Limited, incorporated under the Companies Act, 1929. Since the year 1889, The Bristol Company has enjoyed a very substantial trade with Great Britain, in its complete line of recording instruments, its selling activities in that country being handled by J. W. & C. J. Phillips, Ltd., as sales agent.

Although the general expansion program of the company contemplated the founding of a British plant at some future time, the altered economic and business situation within Great Britain made an earlier establishment for manufacturing in that country seem advisable.

President, Howard H. Bristol, of The Bristol Company, recently made a special trip to London to investigate the situation and during his visit laid the plans and arranged for the formation of the British Company. Mr. Bristol is Chairman of the board of directors and Alexander L. Dugon, of J. W. & C. J. Phillips, Ltd., is vice chairman and managing director.

The plant is located at 144 Pomeroy Street, New Cross, London, and consists of an office building and a new two story factory building of modern construction. The factory is completely equipped with machinery, tools and testing equipment, and with British employees especially trained and skilled in the art of instrument making. It is prepared to manufacture and service the complete line of Bristol's indicating, recording and controlling instruments.

October Plate Glass Production

The total production of polished plate glass as reported by the member Companies to Secretary P. A. Hughes, of the Plate Glass Manufacturers of America, for the month of October, 1932, was 3,935,416 sq. ft.

Performance talks

"Our Brickwork Now Gives Us Twice as Much Service"

Alexander H. Kerr & Co., Inc., Sand Springs, Okla., Mfrs. of glass jars, bottles, etc., write:

"We lay up our ports in Setskold, and also paint the brick work around the ports with Setskold. When patching our regenerators and the fire boxes in our lehrs we use your product exclusively, and find that the brick work gives us twice as much service without repairs as brick work that was formerly laid up without Setskold. The use of Setskold has become a regular part of our repair routine and we recommend it highly."

Setskold is a high temperature refractory mortar. It air sets, and has great bonding strength. Use it for laying up the fire brick in ports and port necks; for laying up the refractory blocks which form the port floors or covers; and as a wash either outside or inside the regenerator walls, to prevent air leakage.

In 100, 250 and 500 pound airtight steel drums. Order a trial drum today.

LACLEDE-CHRISTY, ST. LOUIS, U. S. A.

P-5

SETSKOLD

Air-Setting Refractory Mortar

A LACLEDE-CHRISTY PRODUCT

Current Prices of Glass-Making Materials

November 22, 1932

Quotations furnished by various producers, manufacturers and dealers.

Acid		Carlots	Less Carlots
Citric (dom.)	lb	..	.29
Hydrochloric (HCl) 20° tanks, per 100 lt			1.10
Hydrofluoric (HF) 60% (lead carboy)	lt		.13½
52% and 48%	lt	.10	10-.11½
Nitric (HNO_3) 38° carboy ext. Per 100 lt		5.50	..
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	..
Tartaric	lb	..	.21
Alconol, denatured	gal	..	..
Aluminum hydrate ($Al(OH)_3$)	lb	.04½-.05	05½-.06
Aluminum oxide (Al_2O_3)	lb	..	.07
Ammonium bifluoride (NH_4) FHF	lb	..	.15½
Ammonia water (NH_4OH) 26° drums	lb	..	..
Antimony, metallic (Sb)	lb	.02½	.02¾
Antimony oxide (Sb_2O_3)	lb	..	.09¾
Antimony sulphide (Sb_2S_3)	lb	..	.08½
Arsenic trioxide (As_2O_3) (dense white), 99%	lb	.04	.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	47.00	..
90% through 100 mesh	ton	44.00	..
Barium hydrate ($Ba(OH)_2$)	lb	..	.05¼
Barium mixture, glassmaker's, f.o.b. St. Louis	ton	25.00	..
Barium nitrate ($Ba(NO_3)_2$)	lb	..	.07¼
Barium selenite ($BaSeO_3$)	lb	..	..
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk, f.o.b. shipping point,	ton	15.00-16.00	18.00
Bone ash	carlots, lb	.06	.06
Borax ($Na_2B_4O_7 10H_2O$)	lb	..	..
Granulated	In bags, lb.	.02	.02¼-.02½
Powdered	In bags, lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3)	In bags, lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—			
Red	lb	..	.65-.90
Orange	lb	..	.60-1.10
Yellow	lb		1.30-1.50
Chromium oxide (Cr_2O_3)	lb	.18½	.19
Cobalt oxide (Co_3O_4)			
In bbls.	lb	..	1.15-1.25
In 10 lb. tins	lb	.	1.35
Copper oxide			
Red (Cu_2O)	lb	..	.25
Black (CuO)	lb	..	.17-.19
Black prepared	lb	..	.22
Cryolite (Na_3AlF_6) Natural Greenland Kryolith)	lb	.09	.09¼
Synthetic (Artificial)	lb	..	.09½
Epsom salts ($MgSO_4$) (imported) Per 100 lb		..	1.15-1.20
*Feldspar—			
100 mesh	ton	11.50-17.50	12.00-18.00
80 mesh	ton	11.00-11.50	13.00
40 mesh	ton	10.75-11.00	12.00
20 mesh	ton	9.50-11.00	..
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2 2½%)			
Bulk, carloads, f.o.b. mines	ton	30.00	
In bags or barrels	ton	34.00	39.00
Imported	ton	30.00-31.00	33.00-37.00
Formaldehyde	lb	..	.07
Graphite (C)	lb	..	04-.07
Iron oxide—			
Red (Fe_2O_3)	lb	..	.0425
Black (FeO)	lb	.04½	..
Kaolin (f.o.b. mine)	ton	8.00-9.00	..
English, lump, f.o.b. New York	ton	14.50-25.00	24.50-30.00

*Spot Shipments.

Kryolith (see Cryolite)		Carlots	Less Carlots
Lead chromate ($PbCrO_4$)	lb	..	.30
Lead oxide (Pb_3O_4) (red lead)	lb	.055	.06¾
Litharge (PbO)	lb	.045	.05¾
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	5.50	..
Burnt (CaO) ground, in bulk	ton	5.00	..
Burnt, ground, in paper sacks	ton	7.00	..
Burnt, ground, in 280 lb. bbls.	Per bbl	2.15	..
Limestone ($CaCO_3$)		1.50-2.50	..
Magnesia (MgO)—			
Calcined, heavy (in bbls.)	lb	.06	07
light (in bbls.)	lb	..	23
extra light (in bbls.)	lb	..	.37
Magnesium carbonate ($MgCO_3$)	lb	.06	.10
Manganese 85% (MnO_2)	lb	.03	03
Nickel oxide (Ni_2O_3), black— for nickel content	lb	..	35
Nickel monoxide (NiO), green— for nickel content	lb	..	35
Plaster of Paris, bags	ton	$1.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb	.09	09¼
Ground	lb	11	12
Potassium carbonate—94-96%	lb	.0555	0555
Calcined (K_2CO_3) 96-98%	lb	.06¼	.07
Hydrated 80-85%	lb	.05¾	.06¼
Potassium chromate (K_2CrO_4)	lb	..	.25
Potassium hydrate (KOH) (caustic potash)	lb	07¼	.08
Potassium nitrate (KNO_3) (gran.)	lb	..	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb	.16½	.17½
Powdered blue	lb	..	1.35
Rochelle salts, bbls.	lb	..	.13½
Rouge	lb	..	..
Rutile (TiO_2) powdered, 95%	lb	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	22.00	
Selenium (Se)	lb	..	1.70
Silver nitrate ($AgNO_3$)	(100 oz.) per oz	..	.20
Soda ash (Na_2CO_3) dense, 58%—			
Bulk, on contract	Flat per 100 lb	1.05	..
In barrels	Per 100 lb	1.38	1.90-2.13
In bags	Per 100 lb	1.17½	1.72½-1.92½
Spot orders	.025 per 100 lbs. higher		
Sodium bichromate ($Na_2Cr_2O_7$)	lb	.07	.07½
Sodium hydrate (NaOH) (caustic soda) Solid	Per 100 lt	2.50	..
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	lb	..	3.62
95 per cent	Per 100 lb	1.145-1.245	1.195-1.295
Sodium selenite (Na_2SeO_3)	lb	..	2.00
Sodium fluosilicate (Na_2SiF_6)	lb	.05½	.06
Sodium uranate (Na_2UO_4) Yellow or Orange	lb	..	1.50-1.55
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb	3.45	3.80-4.00
Flowers, in bags	Per 100 lb	3.10	3.45-3.65
Flour, heavy in bbls.	Per 100 lb	2.85	3.20-3.40
Tin chloride ($SnCl_2$) (crystals)	lb	.37½	39
Tin oxide (SnO_2) in bbls.	lb	.28	.29½
Uranium oxide (UO_3) (black, 96% U_3O_4)			
100 lb. lots. Black	lb	..	2.75
Yellow	lb	..	1.50
Zinc oxide (ZnO)	lb	08½	12
American process. Bags	lb	.05¾	.06
Zircon			
Granular (Milled .005-.02c higher)		.07	07½-.08
Crude. Gran (Milled .005-.02c higher)		03½	04-.05

Monthly Summary of United States Foreign Commerce in Glass

EXPORTS

Corrected to Oct. 21, 1932

	September 1931 Quantity	September 1931 Value	September 1932 Quantity	September 1932 Value	Nine Months Ending September 1931 Quantity	Nine Months Ending September 1931 Value	Nine Months Ending September 1932 Quantity	Nine Months Ending September 1932 Value
Glass and glass products (Total)	.....	$539,246	.....	$291,283	.....	$5,513,230	.....	$3,113,362
Plate and window glass—								
Window glass, common, box 50 sq. ft.	359	1,805	98	587	6,338	31,495	1,344	8,217
Plate glass, unsilvered, sq. ft.	208,765	61,049	202,012	48,981	2,930,940	891,748	2,229,957	620,649
Other window and plate glass	230,430	21,326	68,234	12,910	2,247,211	231,166	820,749	109,575
Glass containers (bottles, vials and jars)	.....	186,034	.....	92,365	1,612,992	.....	.....	792,321
Table glassware, plain	.....	92,655	.....	29,164	.....	704,336	.....	370,334
Table and other glassware, cut or engraved	.....	6,250	.....	1,362	.....	64,291	.....	28,535
Lamp chimneys and lantern globes	.....	5,172	.....	2,550	.....	71,785	.....	43,624
Globes and shades for lighting fixtures	.....	35,573	.....	12,640	.....	319,344	.....	159,691
Chemical glassware	12,625	12,242	10,273	10,535	114,201	112,161	85,242	80,490
Electrical glassware, except for lighting	27,502	1,863	27,144	1,989	1,119,340	73,001	649,760	730,426
Other glassware	.....	115,277	.....	78,220	.....	1,337,900	.....	110,069

IMPORTS

Corrected to Oct. 21, 1932

Glass and glass products	.....	$714,900	.....	$421,766	.....	$5,655,989	.....	$2,565,093
Cylinder, crown, and sheet—								
Plain	dut. lb.	223,736	9,211	361,437	11,009	6,261,415	243,773	2,680,770	470,558
Bent, beveled, colored, etc.	dut. lb.	99,988	19,249	74,176	6,429	1,382,094	193,571	981,114	1,827,679
Plate glass	dut. sq. ft.	389,876	64,822	81,942	15,379	3,805,185	932,875	85,490	18,543
Glass mirrors		357	649	430	558	1,407	3,407	430	49,715
Rolled, cylinder, crown, and sheet glass, ground, obscured, bent, beveled, colored, etc.	.....	8,315	.....	3,596	.....	61,047	.....	6,862
Laminated glass and manufactures, and plated glass	.....	97	.....	390	.....	15,899	.....	225,837
Bottles, vials, jars, and other containers	.....	47,115	.....	34,156	.....	283,092	.....	230,878
Scientific articles and utensils	dut.	31,955	.....	21,809	.....	306,823	.....	68,684
Tubes and rods	dut.	10,365	.....	2,482	.....	101,890	.....	136,185
Illuminating articles	dut.	28,298	.....	16,387	.....	274,856	8,441,095	84,463
Blown glass articles—								
Bulbs for electric lamps, without filament	dut.	714,844	5,939	1,108,819	8,098	10,805,854	91,632	1,108,819	610,706
Other blown glass articles	dut.	.....	387,770	.....	255,767	.....	1,372,073	.....	324,244
Pressed glass articles		.....	7,596	.....	7,032	.....	87,739	.....	404,205
Other glassware		.....	93,519	.....	38,674	.....	677,312	.....	38,674

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